

**REMARKS**

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention, and so as to reduce issues remaining in the above-identified application. Specifically, claims 4 and 7 have been amended to delete the recitation, in the step of forming the multilayer film, that this film includes, in addition to an insulation layer, "either polycrystalline silicon or amorphous silicon". Moreover, each of claims 4 and 7 has been further amended, in the recitation of processing the semiconductor substrate to create a trench, to delete the word "having" in the recitation that the multilayer film is used as a mask.

In addition, claim 11 has been amended to recite etching the semiconductor substrate to form upper end portions of a trench in tapered shape "by adhering a reaction product composed of the mixed gas and the semiconductor substrate to the side wall of the mask layer, thereby forming an adhered film"; and to recite etching the semiconductor substrate to form a main trench portion "and removing the adhered film as a mask to round off the upper end portion of the trench in the tapered shape".

Moreover, Applicants have amended claim 12 to delete recitation of the ratio of mixed gas including Cl<sub>2</sub>, O<sub>2</sub> and HBr. Applicants have also amended claims 13 and 14 to recite that the reaction gas includes a halogen system gas selected from the group consisting of CHF<sub>3</sub>, Cl<sub>2</sub> and HBr.

In connection with amendments to claims 4, 7 and 12, note, e.g., the reasons given for claim rejections under the first paragraph of 35 USC 112, set forth in Items 2 and 3 on page 2 of the Office Action mailed January 26, 2005. As to other amendments of the present claims, note, e.g., pages 5 and 6 of Applicants' specification. Note especially the description in the second full paragraph on page 6

of Applicants' specification, that the side walls 14 (see Fig. 4) created (adhered) by the first etching is also somewhat etched, so that the upper end portion projecting in the element isolation region is also etched, thus being connected smoothly with the second etched portion.

Initially, it is respectfully requested that the present amendments be entered. Noting present amendments to claims 4, 7 and 12, and bases for rejection of these claims under the first paragraph of 35 USC 112, in the Office Action mailed January 26, 2005, it is respectfully submitted that these amendments materially limit issues remaining in connection with the above-identified application; and, at the very least, present the claims in better form for appeal, materially simplifying issues remaining in connection with the above-identified application. Moreover, noting recitations in previously considered claim 4, with respect to adhering a reaction product composed at least of the semiconductor substrate and a reaction gas to side wall portions of the multilayer film, it is respectfully submitted that present amendments to claim 11 materially limit issues remaining in the above-identified application, and do not raise any new issues in the claims, including any issue of new matter. Furthermore, it is respectfully submitted that present amendments to claims 13 and 14, which are dependent claims being dependent upon claims not rejected over prior art, do not raise any new issues, including any issue of new matter (note especially the paragraph bridging pages 5 and 6 of Applicants' specification), and are clearly appropriate notwithstanding finality of the Office Action mailed January 26, 2005. Noting new bases for rejection in the Office Action mailed January 26, 2005, and new arguments therein, it is respectfully submitted that the present amendments are timely.

In view of all the foregoing, it is respectfully submitted that Applicants have made the necessary showing under 37 CFR 1.116(c); and that, accordingly, entry of the present amendments is clearly proper notwithstanding Finality of the outstanding Office Action.

Applicants respectfully traverse the rejection of various of the pending claims under the first paragraph of 35 USC 112, as set forth in items 2 and 3 on page 2 of the Office Action mailed January 26, 2005, especially insofar as this rejection is applicable to the claims as presently amended. That is, to facilitate proceedings in connection with the above-identified application, claims 4 and 7 have been amended to delete recitation of either a polycrystalline silicon or amorphous silicon as being included in the multilayer film; and have amended claim 12 to delete recitation of the ratio of the mixed gas. In view of these amendments to claims 4, 7 and 12, it is respectfully submitted that the rejection as set forth in Items 2 and 3 on page 2 of the Office Action mailed January 26, 2005, is moot.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of prior art applied in rejecting claims in the Office Action mailed January 26, 2005, that is, the teachings of the U. S. Patents to Mui, et al., No. 6,235,643, and to Williams, et al., No. 6,589,879, under the provisions of 35 USC 103.

Initially, note that only claims 11 and 12 have been rejected under the provisions of 35 USC 103. With respect to claims 11 and 12, it is respectfully submitted that the references as applied by the Examiner would have neither taught nor would have suggested such a method for manufacturing a semiconductor device as in the present claims, including, inter alia, wherein the etching of the semiconductor substrate using the recited mixed gas, to form upper end portions of

the trench in tapered shape by adhering a reaction product composed of the mixed gas and the semiconductor substrate to the side wall of the mask layer, thereby forming an adhered film; and the etching to form the main trench portion and removing the adhered film as a mask to round off the upper end portion of the trench in the tapered shape, with a desired round-off process being performed by controlling etching time and bias voltage of the step of forming the tapered shape and the step of forming the main trench portion. See claim 11.

In addition, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such method for manufacturing a semiconductor device, having features as discussed previously in connection with claim 11, and additionally wherein the ratio of mixed gas including CHF<sub>3</sub> and HBr is 1:5.

As described, for example, in the second full paragraph on page 6 of Applicants' specification, by providing the etching to form the trench as in the present claims, the upper end portion is connected smoothly with portions of the trench extending from the upper end portion. Sufficient roundness is provided at the upper end portion of the trench without having to perform processes other than etching, such as deposition and thermal oxidation, to the semiconductor device. Note also the last paragraph on page 7 of Applicants' specification.

Mui, et al. discloses a method for etching a trench in a silicon substrate, which can be used to provide a rounded top trench corner, a rounded bottom trench corner or both. A first method for creating a rounded top corner is disclosed, for example, in column 2, lines 13-21; and a second method for creating a rounded top corner is described in the paragraph bridging columns 2 and 3. This patent discloses that in the second top corner rounding method the photoresist residue present after etch of

the silicon nitride hard mask is removed prior to application of the corner rounding method, and that the rounded top corners are obtained by constructing a built-up sacrificial structure on the side wall surfaces of the patterned silicon hard mask, the sacrificial structure being formed during the break-through etch of a silicon oxide layer, the rounded top corners on the silicon trench being formed subsequently, during etch of the silicon trench, with the built-up sacrificial structure being formed from reactants added to the etch gas and from byproducts formed during etching of the silicon oxide adhesion layer itself. See column 5, lines 10-22. Note also column 15, lines 32-50.

It is respectfully submitted that Mui, et al. would have neither taught nor would have suggested such a method as in the present claims, including adhering a reaction product composed of the mixed gas including CHF<sub>3</sub> and HBr and the semiconductor substrate to the side wall of the mask layer, thereby forming an adhered film, and wherein in etching the semiconductor substrate to form the main trench portion the adhered film is removed to round off the upper end portion of the trench in the tapered shape; and additional features of the present claims as discussed in the foregoing.

It is respectfully submitted that the additional teachings of Williams, et al. would not have rectified the deficiencies of Mui, et al., such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art.

Williams, et al. discloses a technique for plasma etching both silicon nitride and silicon oxide. This patent discloses a nitride plasma etching process using an etching gas mixture principally composed of sulfur hexafluoride and a weakly polymerizing hydrofluorocarbon, the preferred example of which is trifluoromethane;

and etching a trench underlying oxide and nitride layers, the nitride etch being continued until it breaks through the oxide and thereafter a bromine-based plasma process forms the trench. See column 3, lines 10-14 and 29-33. See also column 3, line 10, to column 4, line 29.

Even assuming, arguendo, that the teachings of Williams, et al. were properly combinable with the teachings of Mui, et al., it is respectfully submitted that such combined teachings would have neither disclosed nor would have suggested the presently claimed method, including forming of the adhered film, by adhering a reaction product composed of the mixed gas and the semiconductor substrate to the side wall of the mask layer, in etching to form upper end portions of a trench in tapered shape, and removing the adhered film in etching the semiconductor substrate to form a main trench portion, as in the present claims, and advantages thereof as discussed in the foregoing and as described in Applicants' specification.

In the interpretation by the Examiner of the teachings of Mui, et al., set forth in the second paragraph of Item 5, on page 3 of the Office Action mailed January 26, 2005, the Examiner contends that in Mui, et al., the step of processing the semiconductor substrate includes providing a roundness to the upper end portion of the trench by adhering a reaction product composed at least of the semiconductor substrate and a reaction gas to side wall portions of the multilayer film, the Examiner referring to column 8, lines 63-67 of Mui, et al. This portion of Mui, et al. discloses that oxygen can be included in the plasma feed gas for the break-through step, the presence of O<sub>2</sub> during the overetch of the silicon tending to form silicon oxide which may serve as a passivating agent at the edge of the top trench corner; and this patent further goes on to describe, at column 9, lines 1-7, that the presence of the polymeric residue adjacent the side wall of the etched silicon oxide layer, in

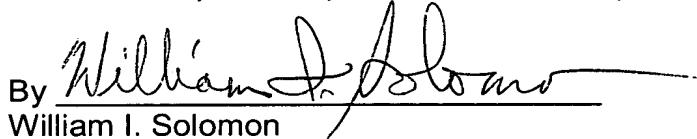
combination with the silicon oxide build-up in the same area during the overetch portion of the break-through step, contribute to formation of the rounded top corner at the upper surface of the silicon substrate during subsequent etching of the silicon trench. It is respectfully submitted that this "polymeric residue" is a residue from the photoresist. It is respectfully submitted that this disclosure in Mui, et al., either alone or in combination with the teachings of Williams, et al., would have neither taught nor would have suggested the process as in the present claims, including adhering a reaction product composed of the mixed gas and the semiconductor substrate to the side wall of the mask layer, thereby forming an adhered film, in forming the upper end portion of a trench in a tapered shape; much less wherein this adhered film is removed, in etching to form the main trench portion, to round off the upper end portion of the trench in the tapered shape, and advantages thereof as discussed previously.

In view of the foregoing comments and amendments, entry of the present amendments, and reconsideration and allowance of all claims presently in the application, are respectfully requested.

Applicants request any shortage or excess in fees in connection with the filing of this paper, including extension of time fees, and for which no other form of payment is offered, be charged or credited to Deposit Account No. 01-2135 (Case: 648.41969CX1).

Respectfully submitted,

**ANTONELLI, TERRY, STOUT & KRAUS, LLP**

By   
William I. Solomon  
Registration No. 28,565

WIS/ksh  
1300 N. Seventeenth Street  
Suite 1800  
Arlington, Virginia 22209  
Tel: 703-312-6600  
Fax: 703-312-6666  
April 26, 2005